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JBoss Drools - Viva Le Drools

Declarative Behavioural Modelling

An Integrated AI approach

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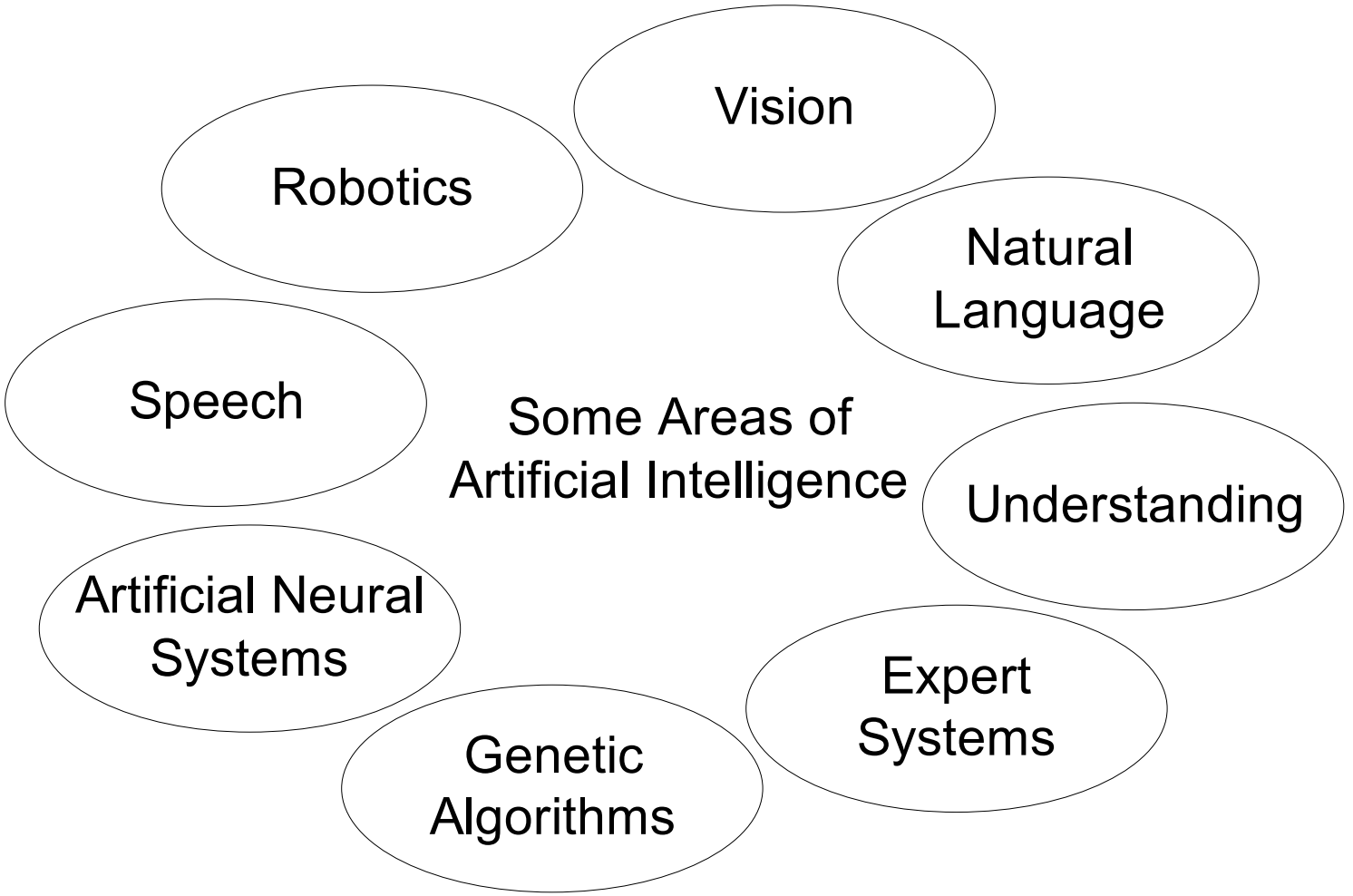
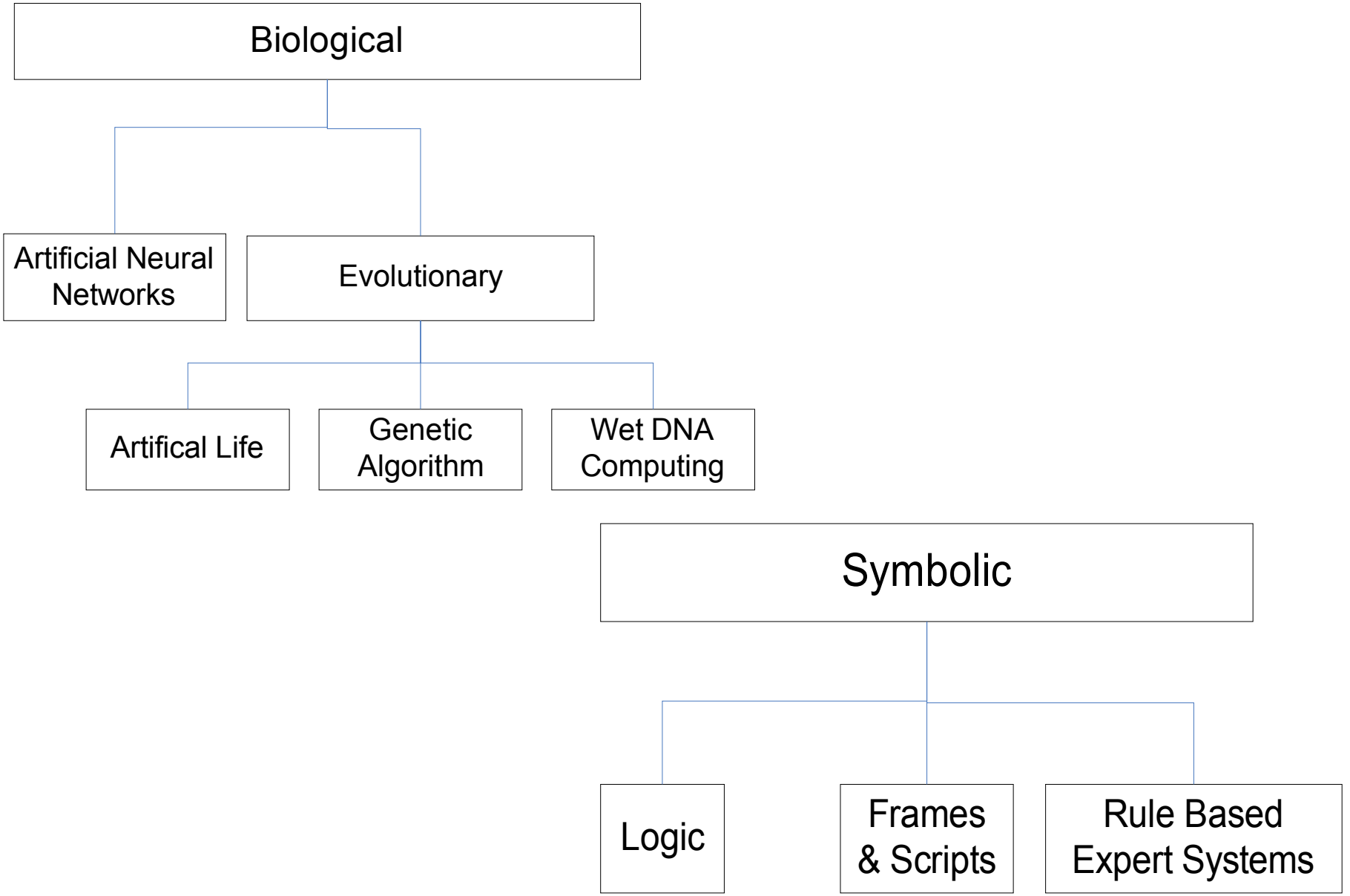
- The SkyNet funding bill is passed.
- The system goes online on August 4th, 1997.
- Human decisions are removed from strategic defense.
- SkyNet begins to learn at a geometric rate.
- It becomes self-aware at 2:14am Eastern time, August 29th
- In a panic, they try to pull the plug.
- And, Skynet fights back

Artificial Intelligence

Making computers think like people

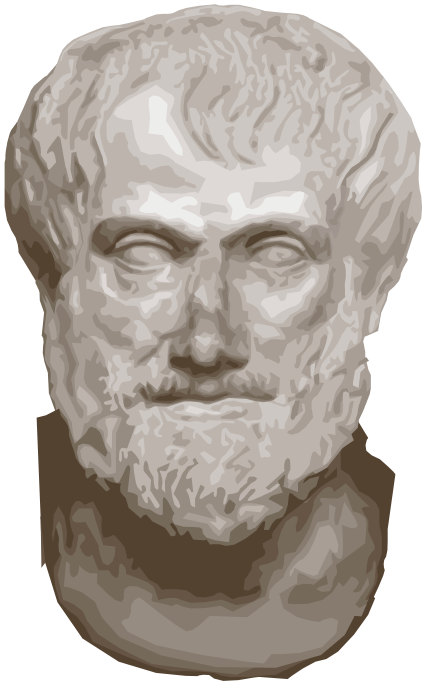


Branches of AI



Expert Systems - Knowledge Representation and Reasoning

- The study of Knowledge is Epistemology
- Nature, Structure and Origins of Knowledge



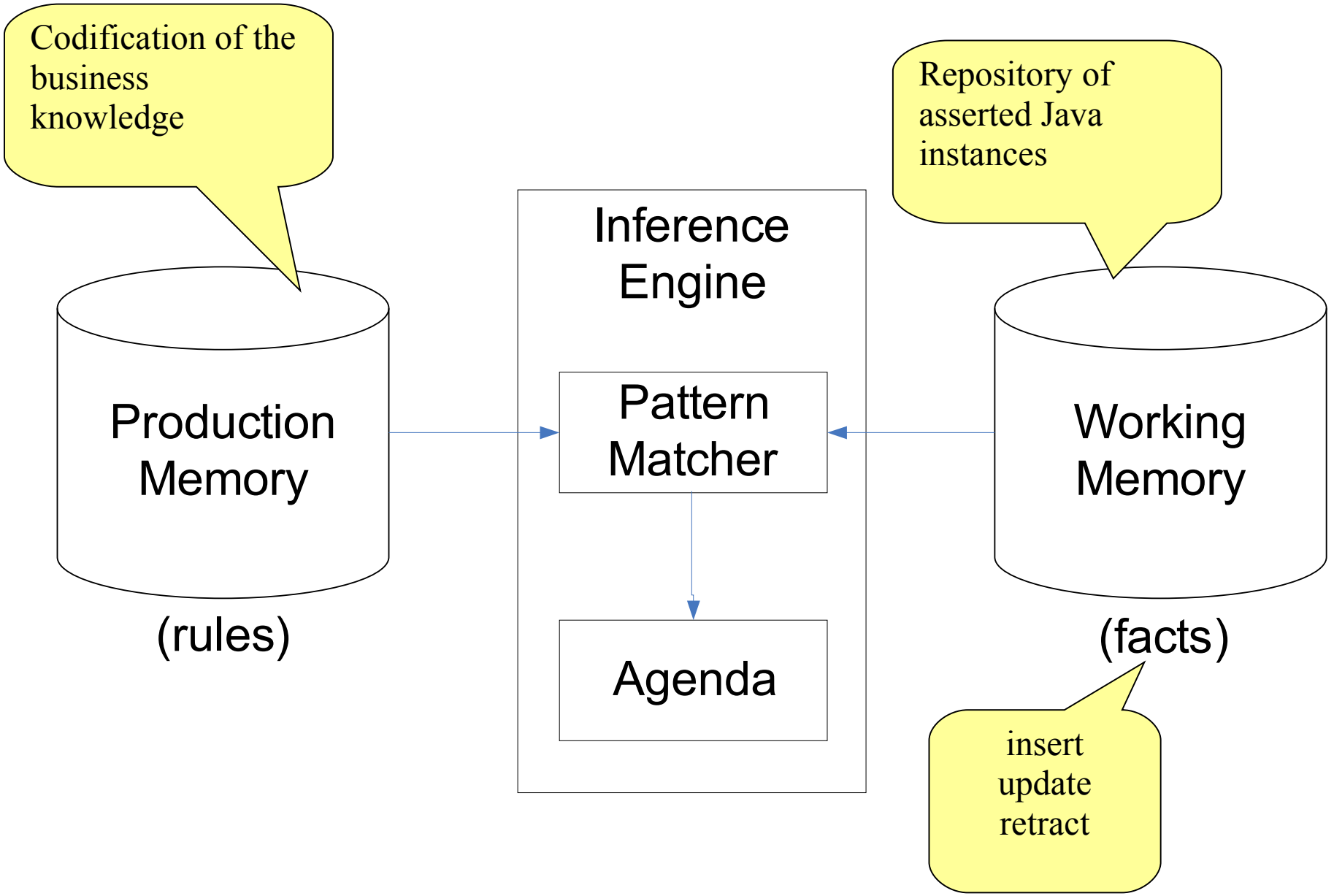
- Expert Systems use Knowledge representation to facilitate the codification of knowledge into a knowledge base which can be used for reasoning
  - we can process data with this knowledge base to infer conclusions

Production Rule System

- Turing Complete
  - Propositional Logic
  - First Order Logic
- The Brain is the Inference Engine
  - scale to a large number of rules and facts
  - matches facts, the data, against Production Rules, also called Productions or just Rules, to infer conclusions which result in actions
  - A Production Rule is a two-part structure using First Order Logic for knowledge representation.

  when <conditions> then <actions>
  - The process of matching the new or existing facts against Production Rules is called Pattern Matching

What is a Production Rule System



What is a Rule

Quotes on Rule names are optional if the rule name has no spaces.

```
rule "<name>"
    <attribute> <value>
    when
        <LHS>
    then
        <RHS>
end
```

salience <int>
agenda-group <string>
no-loop <boolean>
auto-focus <boolean>
duration <long>

RHS can be any valid java. Future versions will support other languages, i.e Groovy

What is a Rule

Methods that must be called directly

specific passing of instances

```
public void helloMark(Person person) {
    if ( person.getName().equals( “mark” ) {
        System.out.println( “Hello Mark” );
    }
```

Rules can never be called directly

Specific instances cannot be passed.

```
rule “Hello Mark”
    when
        Person( name == “mark” )
    then
        System.out.println( “Hello Mark” );
end
```

LHS

RHS

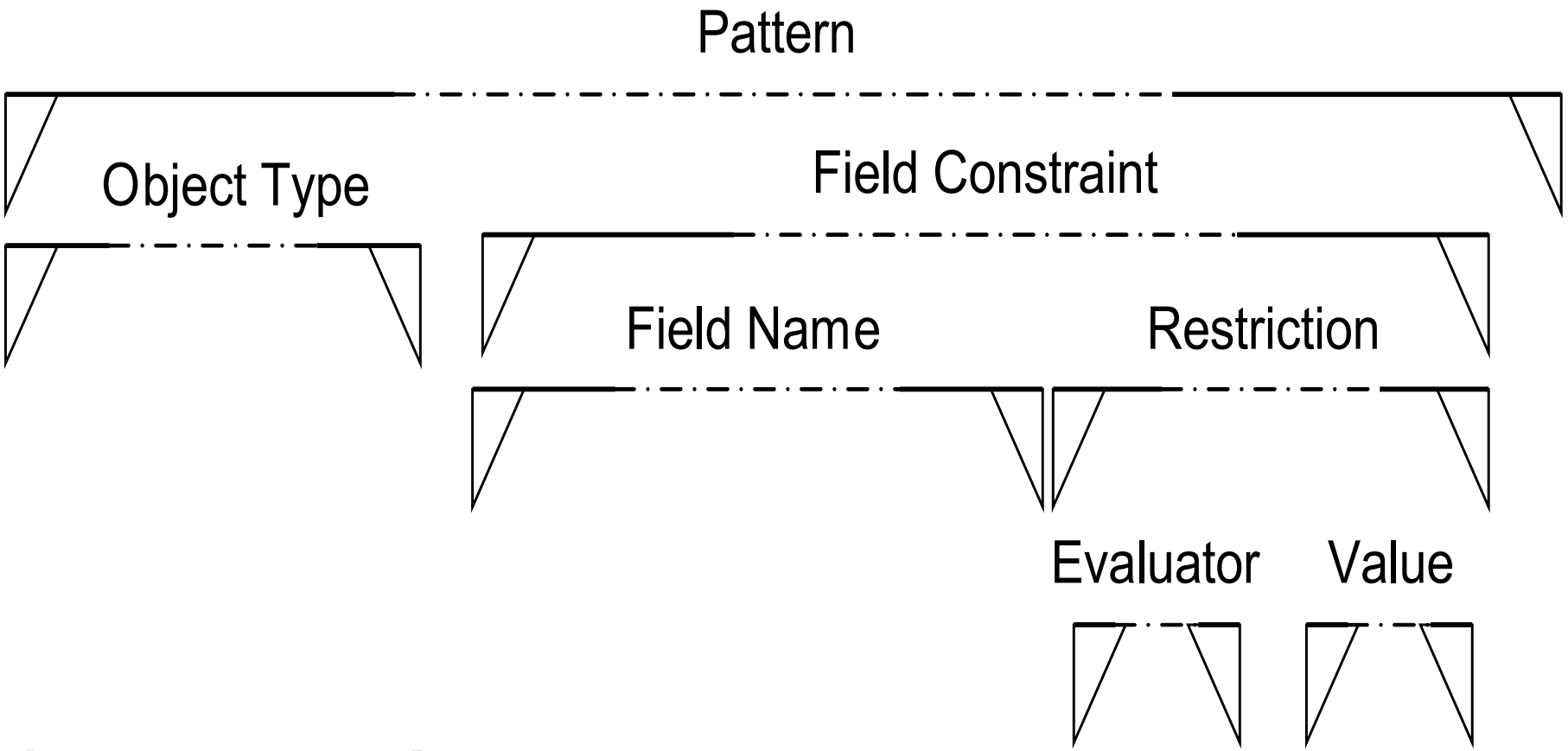
Package

Namespace for all package members

Imports can be used in functions and rules. Uses valid java import syntax

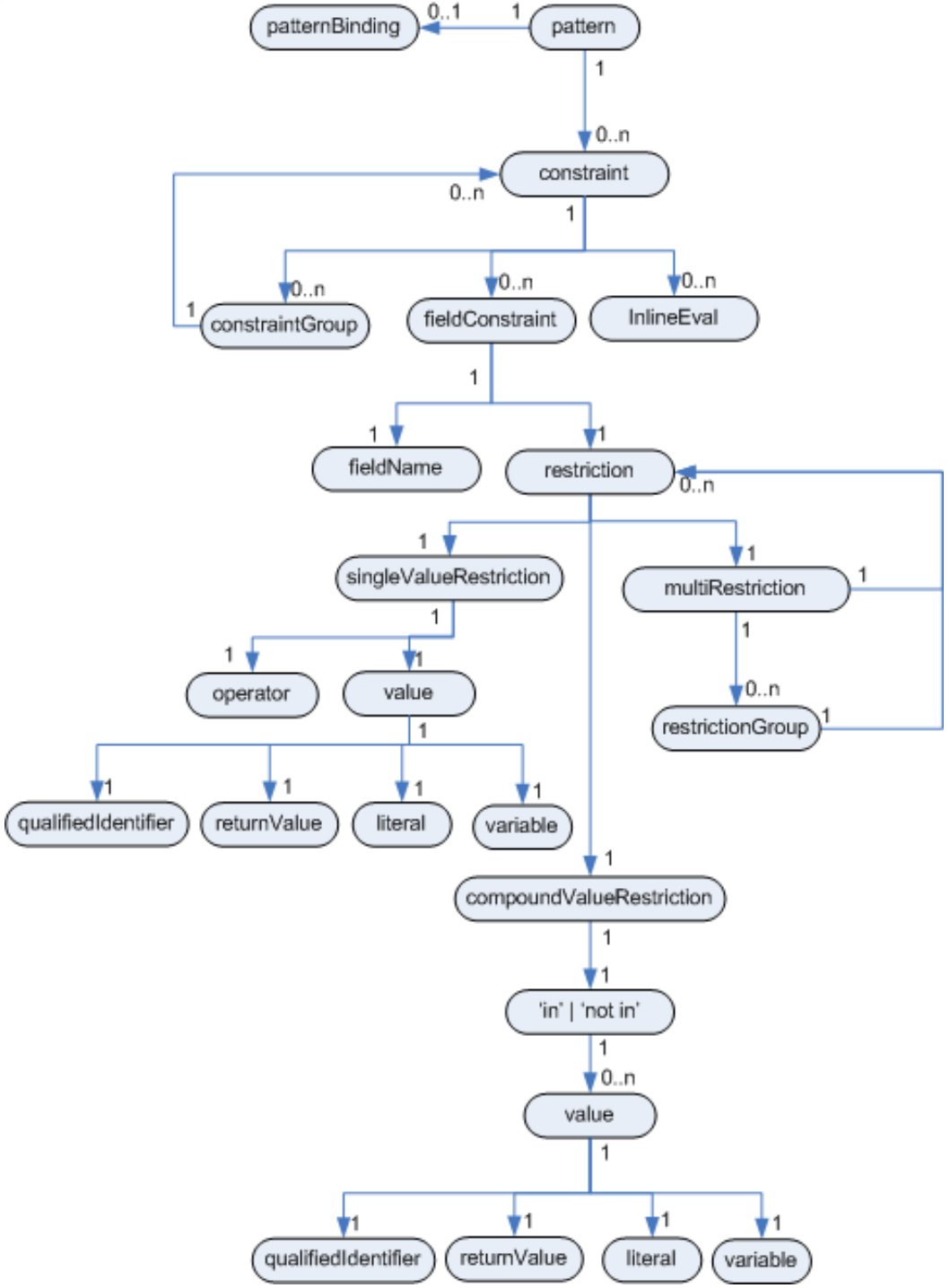
```
package com.sample

import java.util.Map
import com.sample.Cheese

global Cheese cheese

function void exampleFunction(Cheese cheese) {
    System.out.println( cheese );
}

rule “A Cheesy Rule”
    when
        ….
    then
        ….
end
```

Simple Pattern

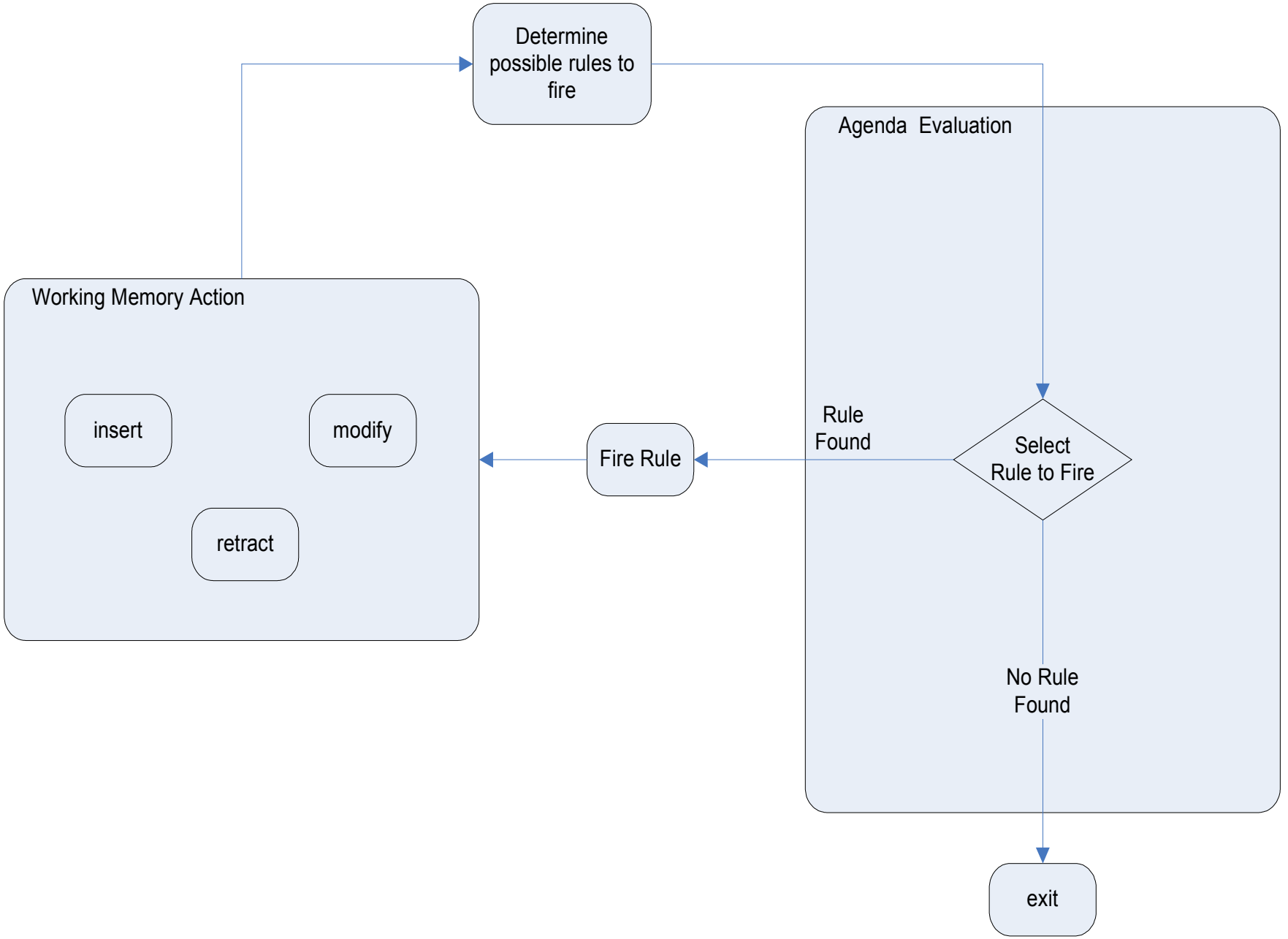


Shower(temperature == “hot”)

Anatomy of a Pattern



Two Phase System



Drools | Features

- Engine
  - Full Rete Implementation -- with high performance indexing
  - Dynamic RuleBases
  - Stateful and Stateless Execution Modes
  - Async operations
  - Rete and Sequential Rete
  - Rule Agent
  - Optional Data Shadowing
  - Pluggeable Dialects
- Propositional Logic
  - Literal Restriction
  - Variable Restriction
  - Return Value Restriction
  - Jointed and dis-jointed Connectives allowed - '&&' '||'
  - inline-Eval

Features

- First Order Logic (Quantifiers)
  - And
  - Or
  - Exists
  - Not
  - Accumulate
  - Collect
  - From
  - Forall
  - Nesting of any CE inside of 'and' and 'or'
  - Support for both infix and prefix 'and'/'or' CEs
  - Nesting and Chaining of 'from', 'accumulate', 'collect'

Features

- Execution Control
  - Conflict Resolution (salience) Now pluggeable
  - Agenda Filters
  - Agenda Groups
  - Activation Groups
  - Rule Flow
  - Attributes (no-loop, lock-on-active)
- Temporal Rules
  - Scheduler for rule duration will fire when a rule is true for X duration
- Truth maintenance
  - Logical Insertions
- Event Model
  - Working Memory, Agenda, Rule Flow and Rule Base

Drools | Features

- Configurable
  - All Rete optimizations and execution behavior can be configured
- Authoring
  - Technical rules: DRL and XML formats supported
  - Template based DSLs
  - Guided Editor
  - BRMS and Eclipse
  - Decision Tables (Excel, Open Office)
- BRMS (Knowledge Asset Management System)
  - Authoring and Storage DRLs, RuleFlows, Decision Tables, Business Rules (Guided Editor)
  - Multi level Versioning, at both the rule and package level
  - Classification
  - Deployment
  - Built on Standards and Open APIs - JCR (JSR 170) Dublin Core, GWT

More Expression Flexibility

- 3.0.x only allows comma separated field constraints. 'or' could be used at the CE level, but resulted in subrule generation.
  - Can now use && and || inside the pattern for multiple values on the same field and across files - no subrule generation.
  - Can be as deeply nested as you like...
- Old
  - Person(age > 30, age < 40) OR Person (hair == “black”)
- New
  - Person(age > 30 && < 40 || hair == “black”)

More Expression Flexibility

- Auto vivification of variables in dialect
- Old
  - Cheese(oldPrice : oldPrice, new Price == (oldPrice * 1.10))
- New
  - Cheese(newPrice == (oldPrice * 1.10))
- Drools 3.0 only supported infix 'and'/or' constraints, which is idea for some situations but more complicated to read for others
- Old
  - Person(name == "matthew") or Person(name == "john")
- New
  - (or Person(name == "matthew")
    Person(name == "john"))

More Expression Flexibility

- 3.0.x had to always declare the variable, causing clutter, can now access direct properties of pattern variables.
- Old
  - p: Person (personId : id)
    i: Item (id == personId, value > 100)
- New
  - p: Person()
    i: Item(id == p.id, value > 100)
- Eval rewrite for complex expressions, engine works out best way to do it - of course, flat models work best for performance.
- Old
  - Person($pets : pets) eval ($pets.get('rover').getType().equals("dog"))
- New
  - Person(pets['rover'].type == "dog")

More Powerful CEs

- 3.0:
  - 'and'
  - 'or'
  - 'not' Could only nest a single Pattern
  - 'exists' Could only nest a single Pattern
- 4.0:
  - 'forall'
  - 'from'
  - 'collect'
  - 'accumulate'
  - 'not' - Now allows any nested CE
  - 'exists' - Now allows any nested CE

More Powerful CEs

- 'forall', true when the pattern is true for all facts
  - forall(Bus (color==”red”))
- 'from', Pulls and unifies against non-working memory data (can call Hibernate queries)
  - Restaurant (rating == “fivestar”)
    from hbSession
    .getNamedQuery (”restaurant query”)
    .setProperties ([key1 : value1, key2 : value2])
    .list()

More Powerful CEs

- Collect - Allows you to use cardinality eg: when there are more than 6 red buses:
  - List(size > 6) from collect (Bus(color == “red”))
- 'from' can be chained and nested. Following is true if all items in a cart have a price greater than 10
  - List(size == ($list.size)) from collect(Item(price > 10)) from $cart.items Accumulate
- More powerful 'accumulate' allows you to execute actions on each matched fact in the set
  - $total : Integer()
    from accumulate($item : Item( )
    init(count = 0; total=0)
    action(count++;total += $item.price)
    result(return total/count))
- Accumulate functions, built in and user defineable
  - $total : Integer()
    from accumulate(Item($p : price)
    average($ p))

Questions?

- Dave Bowman: All right, HAL; I'll go in through the emergency airlock.
- HAL: Without your space helmet, Dave, you're going to find that rather difficult.
- Dave Bowman: HAL, I won't argue with you anymore! Open the doors!
- HAL: Dave, this conversation can serve no purpose anymore. Goodbye.

Joshua: **Greetings, Professor Falken.**
Stephen Falken: **Hello, Joshua.**
Joshua: **A strange game. The only winning move is not to play. How about a nice game of chess?**

Overview

- **Managing large rule sets**
- Ruleflow
  - Language
  - Execution
  - How does it work?
  - Future
- An integrated approach to rules and processes

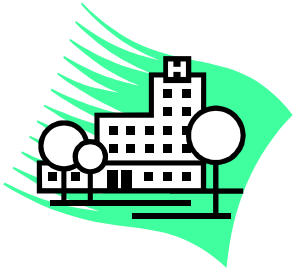
Example: Clinical DS

- Use rules to define clinical knowledge
  - Validation rules
  - Safety
  - Diagnosis assistance
  - Patient treatment
  - Authorization rules
  - ...

Clinical Pathways

Different Stages

General Treatment Guidelines



Hospital Policies

Administrative Rules

Law

Managing large rule sets

- Ideally, multiple rule sets can be combined into one knowledge base
  - Additive knowledge
- But rules are contextual
  - Explicitly specifying this context as part of the rule conditions makes the rules
    - More complex
    - Harder to reuse

Influencing execution order

Specifying the order in which rules should be executed:

- Purely declaratively
- Using salience (priorities)
- Using a control fact
- Using agenda-groups
- Dynamically adding / removing rules
- Manually loading rule sets and firing rules
- ...

Influencing execution order

- Taking into account:
  - Complexity
    - Keep rules simple
  - Understandability
    - Do not lose overview
  - Scalability
    - Lots of different rule sets
  - Performance
    - Without sacrificing performance

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Ruleflow

A graphical flow chart that defines the order in which rule sets should be evaluated

- Rules are grouped into rule sets
- Flow chart allows you to express
  - Sequence
  - Parallelism (split / join)
  - Choice
  - ...

Ruleflow Group

Grouping rules into ruleflow groups by using a special `ruleflow-group` rule attribute

```
rule 'YourRule'
   ruleflow-group 'group1'
   when
        ...
   then
        ...
end
```

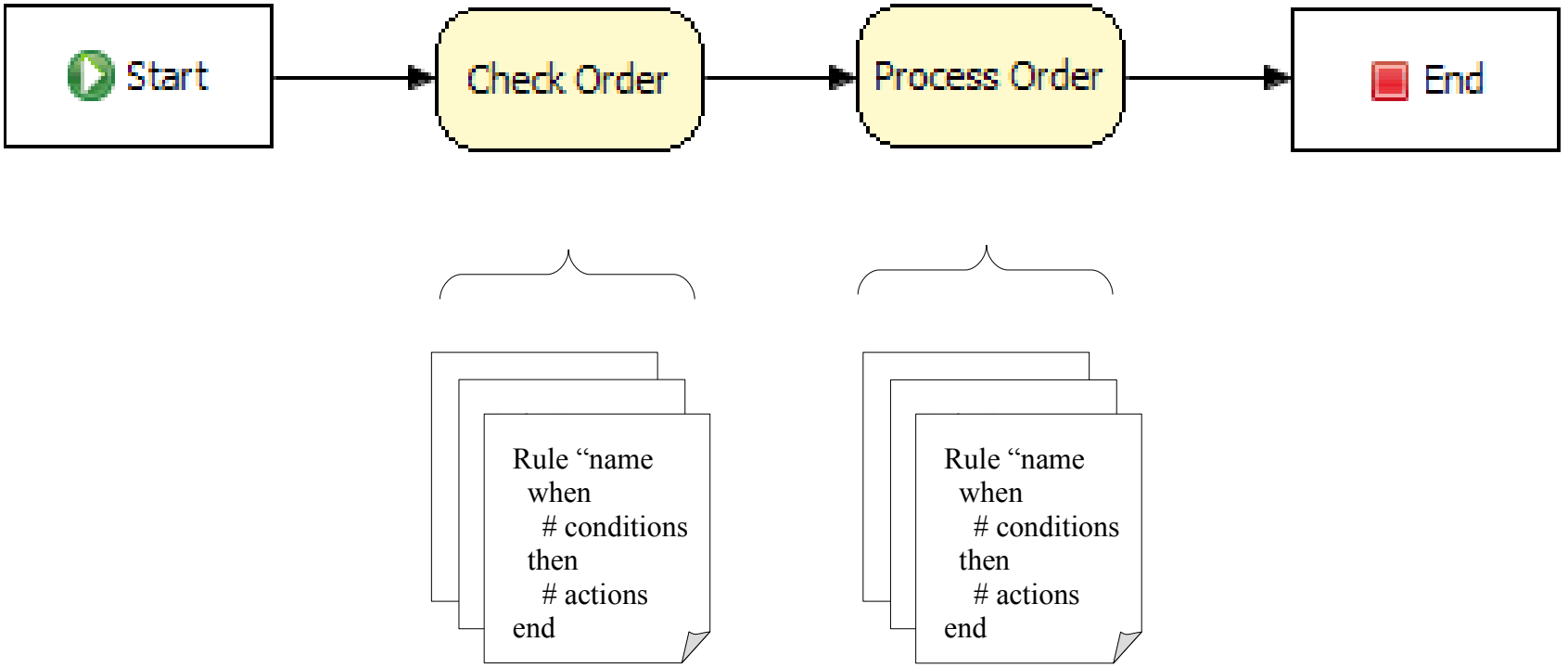
Drools | Ruleflow

A domain-specific workflow language

- Workflow concepts in the context of rule evaluation
  - Supporting relevant workflow patterns
- Execution tightly integrated into rules engine
  - Avoid overhead by having to integrate with external engine
  - Allow usage of all rule features in combination with ruleflow
- Use the power of rules inside the ruleflow itself
  - Rules can used as a powerful condition and actions language

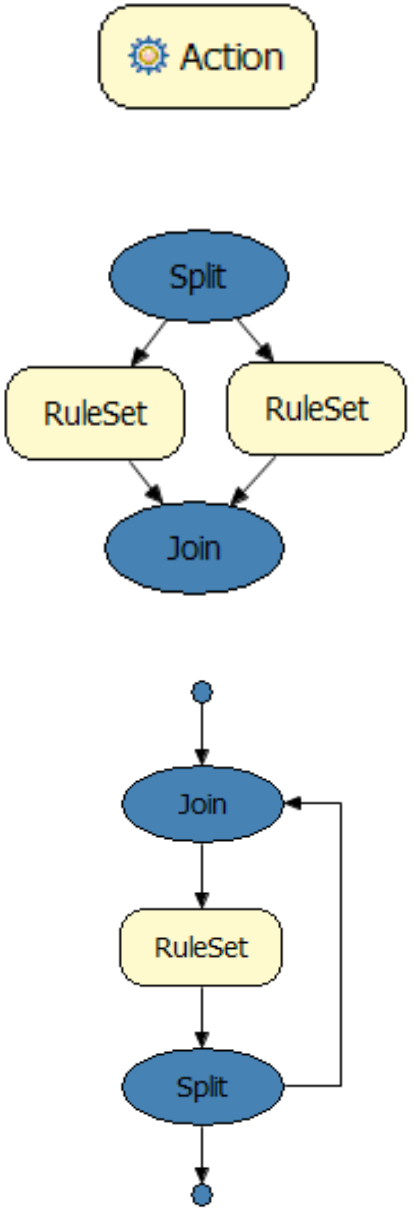
Ruleflow: Example

"When processing orders, make sure to first validate the order before processing it."



Ruleflow features

- Rule set nodes
- Control flow
  - Sequence
  - Parallelism (split / join)
  - Choice
- Nodes
  - Actions
  - Milestone (= state)
  - Subflows
  - Looping



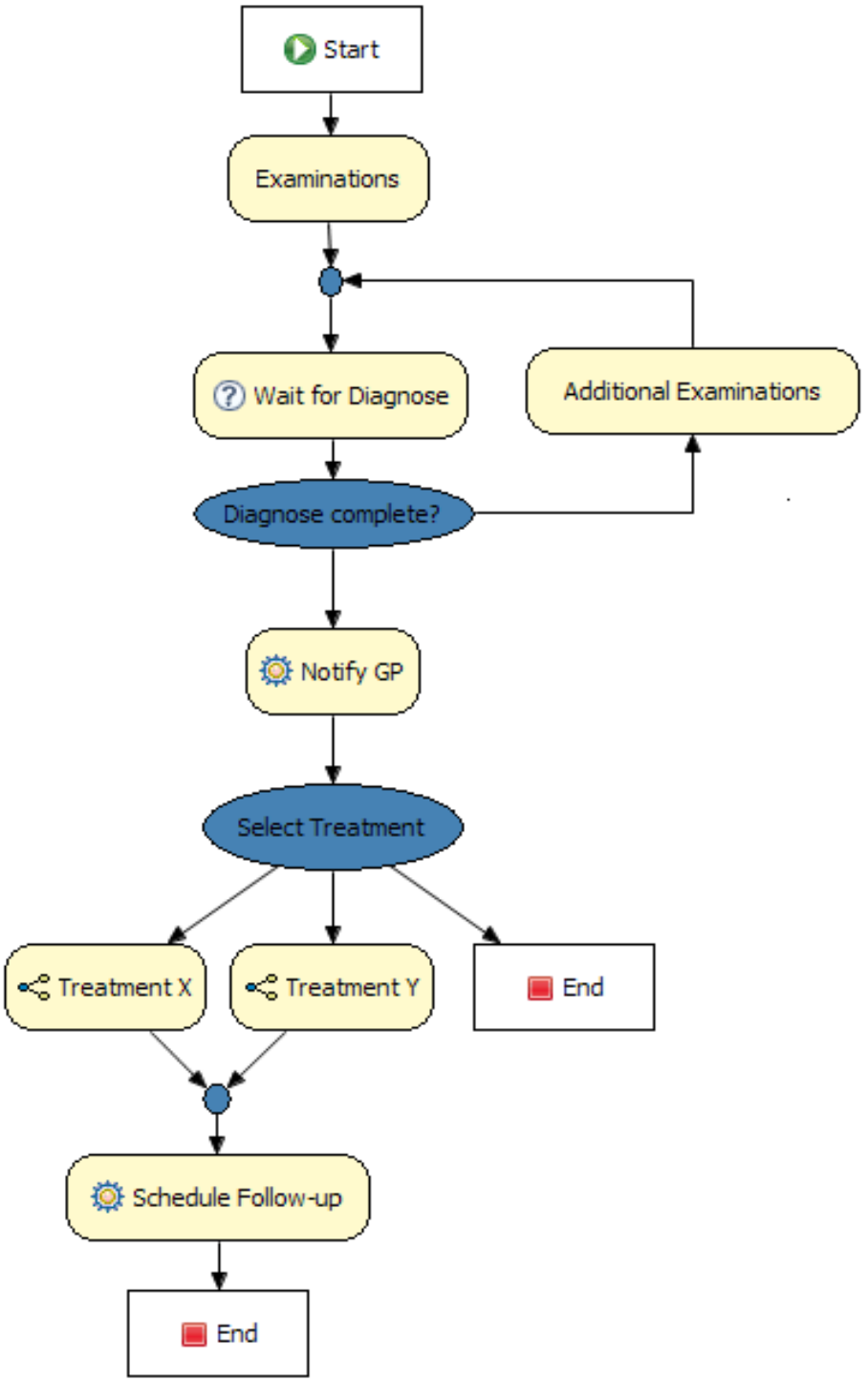
Using rules inside ruleflow ...

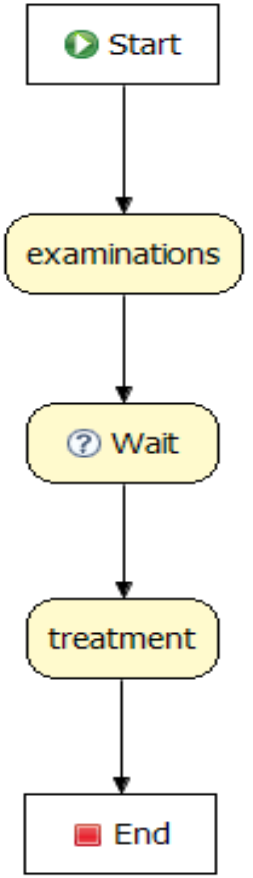
Using rules inside ruleflow

- as part of ruleflow groups
- as constraint expression language, e.g.
  - Split constraints
  - Milestone constraints
- as action language, e.g.
  - Action of an action node

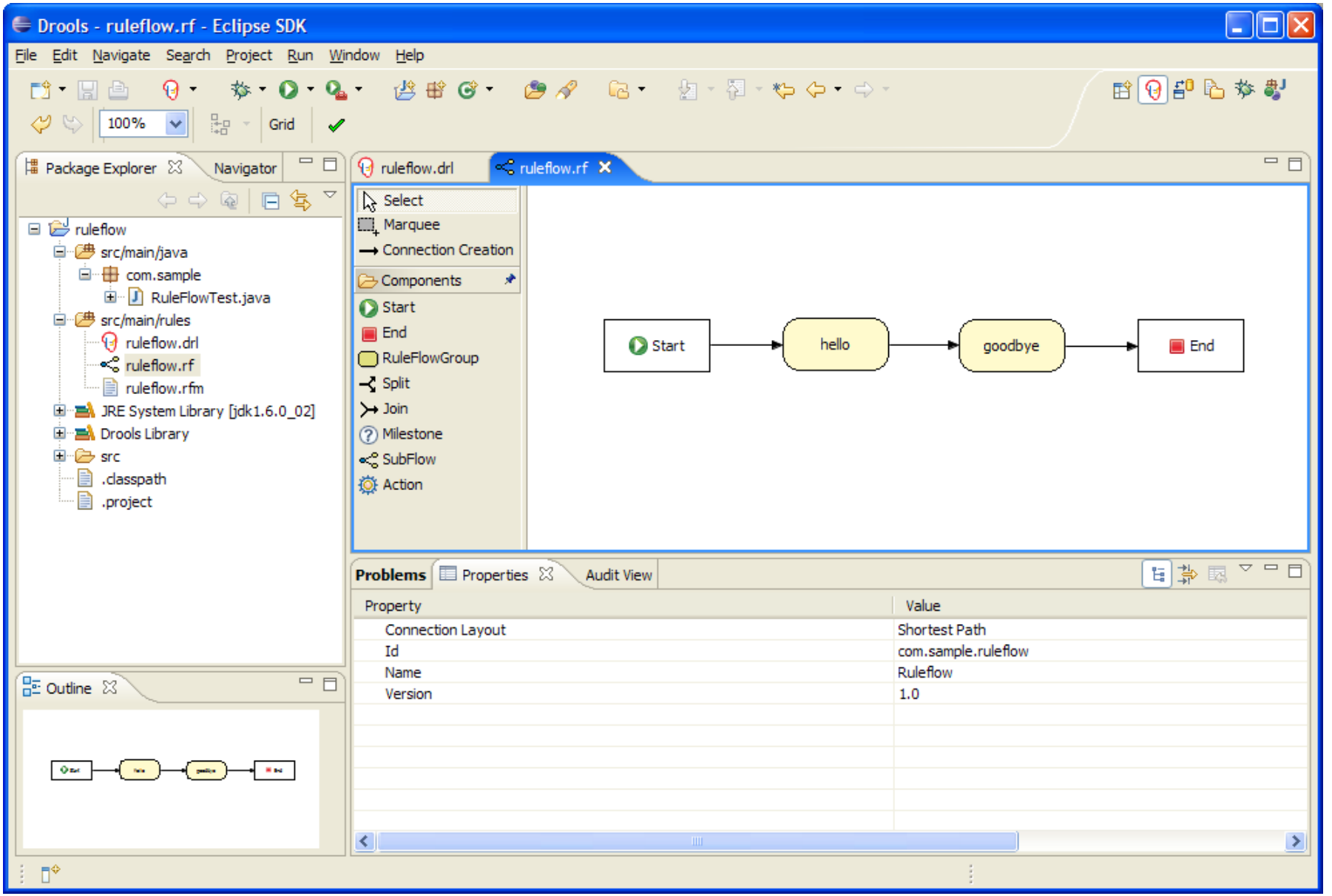
Extended Example: Clinical DS

- Clinical pathways
  - Describes the treatment of patients having a particular disease
- Use rules to model the recommended treatment of patients
  - Different rule sets for different stages of the treatment
  - Use ruleflow to describe the overall flow
- Multiple ruleflow instances can coexist and influence each other
  - by inserting, updating or removing facts


Start
Examinations
Wait for Diagnose
Additional Examinations
Diagnose complete?
Notify GP
Select Treatment
Treatment X
Treatment Y
End
Schedule Follow-up
End


Start
examinations
Wait
treatment
End

Ruleflow designer (Eclipse)



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  - **Execution**
  - How does it work?
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Executing ruleflows

- Ruleflow instance
  - Whenever a ruleflow process is executed, a new ruleflow process instance is created that represents that specific execution of the ruleflow process
  - A ruleflow can be executed more than once
  - Multiple process instances (even of the same process) can coexist
- No limitations
  - Can be used in combination with normal rules
  - Can use all rule features like agenda groups, salience, etc.

Executing ruleflows

Ruleflows are part of the rule base

```
PackageBuilder builder =
    new PackageBuilder();
packageBuilder.addPackageFromDrl(...);
packageBuilder.addRuleFlow(...);
Package pkg = builder.getPackage();
RuleBase ruleBase =
RuleBaseFactory.newRuleBase();
ruleBase.addPackage( pkg );
```

Executing ruleflows

- Ruleflow processes should be started whenever necessary
  - Programmatically
    - `workingMemory.startProcess(id)`
  - From inside rules
    - `drools.getWorkingMemory().startProcess(id)`
- Why manually?
  - Engine cannot (currently) automatically determining when a ruleflow should be started

Overview

- Managing large rule sets
- **Ruleflow**
  - Language
  - Execution
  - **How does it work?**
  - Future
- An integrated approach to rules and processes

How does it work?

- Ruleflow-groups
  - Activations for rules that are part of a ruleflow are not automatically put on the agenda
    - Ruleflow-group acts as a bucket
    - Once a ruleflow-group is activated, its activations are allowed to continue
    - Ruleflow-group deactivates if the bucket is empty
- Constraints
  - Constraints are translated into rules and become part of the Rete network
    - Automatic evaluation of constraints by the rules engine
    - Take advantage of optimizations in rules engine
- Actions
  - Interpreted at runtime

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  - **Future**
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Future extensions to ruleflow

- Extend control flow capabilities
  - Workflow patterns
- Extend data capabilities
  - Variables (different scopes)
- Extend node types
- Extend execution engine
  - Transaction support
  - Persistence
  - Distributed execution

Overview

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  - Execution
  - How does it work?
  - Future
- **An integrated approach to rules and processes**

Choose, integrate and unify

- A knowledge base can contain knowledge in different formats
  - Rules
  - Decision tables / trees
  - Domain-specific (rule) languages
  - Ruleflow
  - ...
- Business expert can ***choose*** most appropriate "language" to model its business knowledge

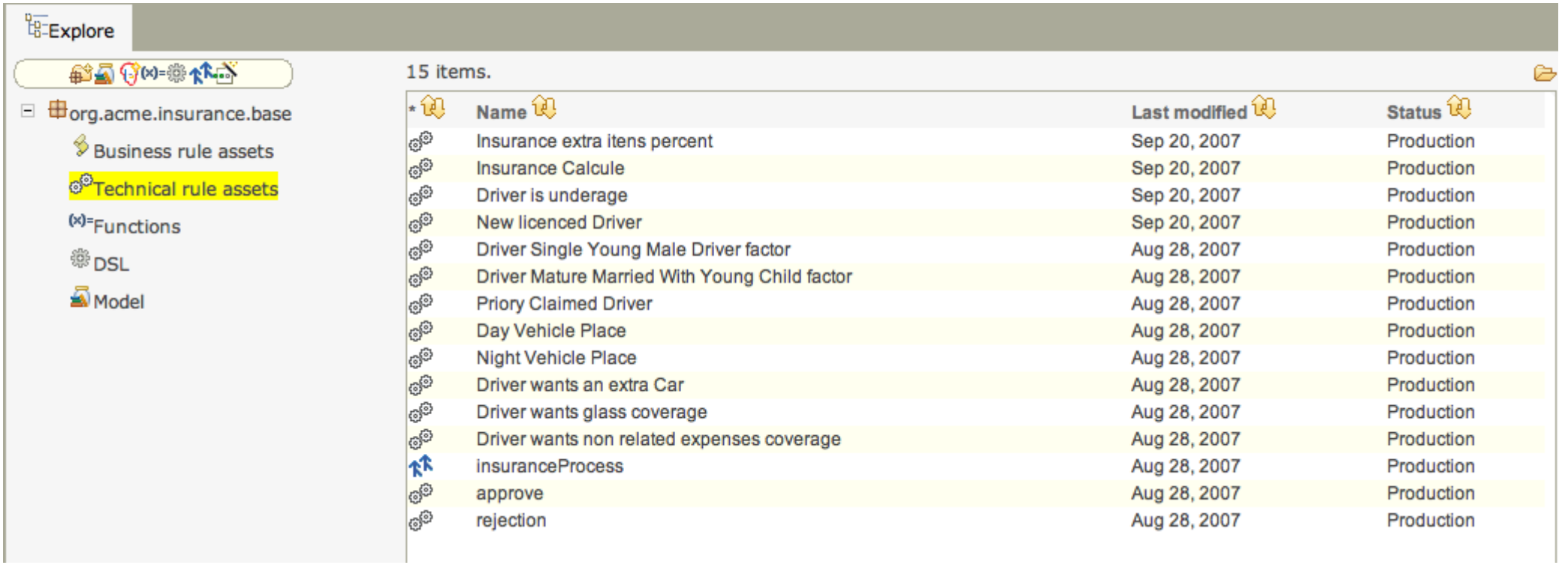
Choose, integrate and unify

- Seamless ***integration*** between rules and processes
  - Processes can more easily embed rules for decision making
    - No complex integration
  - Rules can more easily interact with processes
    - Invoking processes from inside rules
    - Shared data

Choose, integrate and unify

- ***Unified*** approach to manage rules and different types of processes
  - Authoring environment
    - Plug in custom editors
  - Repository
  - Packaging + deployment
  - Execution (API)
  - Management, audit
  - Analysis
  - ...

Unified repository



Unified auditing

- Activation executed: Rule Start Clinical Pathway X if diagnosed d=Diagnose: Diagnose disease X: Type unknown(2)
  - Object removed (2): Diagnose: Diagnose disease X: Type unknown
    - Activation cancelled: Rule RuleFlow-org.drools.examples.cdss.ClinicalPathwayX-16-17
    - Activation cancelled: Rule Remove old diagnose d=Diagnose: Diagnose disease X: Type unknown(2)
    - Activation cancelled: Rule RuleFlow-org.drools.examples.cdss.ClinicalPathwayX-12
  - RuleFlowGroup activated: Examinations[size=2]
  - RuleFlow started: ClinicalPathwayX[org.drools.examples.cdss.ClinicalPathwayX]
- Activation executed: Rule Examination1
- Activation executed: Rule Examination2
- RuleFlowGroup deactivated: Examinations[size=0]
- RuleFlowGroup activated: AdditionalExaminations[size=2]
- Object inserted (2): Diagnose: Diagnose disease X: Type unknown
  - Activation created: Rule Start Clinical Pathway X if diagnosed d=Diagnose: Diagnose disease X: Type unknown(2)
  - Activation created: Rule RuleFlow-org.drools.examples.cdss.ClinicalPathwayX-16-17
  - Activation created: Rule Remove old diagnose d=Diagnose: Diagnose disease X: Type unknown(2)
  - Activation created: Rule RuleFlow-org.drools.examples.cdss.ClinicalPathwayX-12
- Activation executed: Rule Remove old diagnose d=Diagnose: Diagnose disease X: Type unknown(2)
  - Object removed (2): Diagnose: Diagnose disease X: Type unknown
    - Activation cancelled: Rule Start Clinical Pathway X if diagnosed d=Diagnose: Diagnose disease X: Type unknown(2)
    - Activation cancelled: Rule RuleFlow-org.drools.examples.cdss.ClinicalPathwayX-16-17
    - Activation cancelled: Rule RuleFlow-org.drools.examples.cdss.ClinicalPathwayX-12
- Activation executed: Rule Examination3
- RuleFlowGroup deactivated: AdditionalExaminations[size=0]
- RuleFlow completed: TreatmentY[org.drools.examples.cdss.TreatmentY]
- RuleFlow started: TreatmentY[org.drools.examples.cdss.TreatmentY]
- RuleFlow completed: ClinicalPathwayX[org.drools.examples.cdss.ClinicalPathwayX]
- Object inserted (2): Diagnose: Diagnose disease X: Type 2

Drools as a platform

Choose, integrate, unify !

- Supports different process models
- Integrated approach
- Plugging in new
  - Domain-specific extensions
    - Translation
  - Extend existing models
    - E.g. new node type
  - Plug in your own model

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